

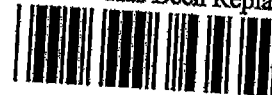
**MULTI-LAYER CERAMIC ELECTRONIC PART****BACKGROUND OF THE INVENTION****FIELD OF THE INVENTION**

The present invention relates to electronic parts, in particular to multi-layer ceramic electronic parts having a structure in which a plurality of internal electrodes are disposed throughout a ceramic layer in a ceramic element.

DESCRIPTION OF THE RELATED ART

In one type of surface-mounted type ceramic electronic part, for example as shown in Fig. 3, at both ends of a rectangular paralleliped-shaped ceramic element 33 in which a plurality of electrodes (internal electrodes) 32 are disposed so as to face each other via a ceramic layer 31, there are ceramic electronic parts (multi-layer ceramic capacitors) 35 which have a structure wherein external electrodes 34 are disposed so as to be conductive with the internal electrodes 32.

This type of ceramic electronic part has become more and more miniaturized with the continued miniaturization of electronic devices, and has resulted in an extremely compact ceramic electronic part such as the ceramic element 33 shown in Fig. 2, whose length (L) is 1.0mm or less and height (H) and width (W) are 0.5mm or less. Also, in such a ceramic electronic part, the distance (thickness of a ceramic outer



layer portion 36) t_1 from the internal electrode 32 (32a) of the outermost layer to the surface of the ceramic element 33 is very small at 0.10mm or less.

However, in the field of miniaturization described above, ceramic electronic parts in which the thickness t_1 of the ceramic outer layer portion 36 is small have little mechanical strength (resistive strength etc.), and in a case where they are handled in bulk by a chip mounting device for example, because cracks in the ceramic element occur easily due to mechanical impacts, as shown in Fig. 4(a) and (b), cracks C occur across the plurality of internal electrodes 32, resulting in the problem of the desired characteristics becoming unattainable.

SUMMARY OF THE INVENTION

The present invention is intended to solve the above problem, and has as its object to provide a highly reliable multi-layer ceramic electronic part which is compact, has sufficient mechanical strength (resistive strength etc.), and in cases where it is handled in bulk by a chip mounting device, is not susceptible to cracks in the ceramic element due to mechanical impacts.

In order to achieve the above object, the inventors performed various tests and studies and found that, by setting the thickness of the ceramic outer layer portion to



a predetermined ratio with respect to the thickness of the portion where the internal electrodes were disposed, resistive strength etc. could be improved and it was possible to suppress the occurrence of cracks. The present invention was arrived at as a result of this discovery, after further tests and studies.

In other words, the multi-layer ceramic electronic part of the present invention, in which, in a ceramic element whose length (L) is 1.0mm or less, height (H) is 0.5mm or less and width (W) is 0.5mm or less, a plurality of electrodes (internal electrodes) are laminated so as to face each other via a ceramic layer and a distance (thickness of a ceramic outer layer portion) t_1 from an internal electrode of an outermost layer to a surface of the ceramic element is 0.10mm or less, it characterized in that the thickness t_1 of the ceramic outer layer portion is a quarter or more of a thickness t_2 of a portion where the internal electrodes are disposed.

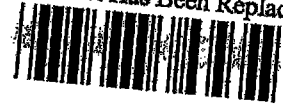
As described above, by setting the thickness t_1 of the ceramic outer layer portion to one quarter or more of the thickness t_2 of the portion where the internal electrodes are disposed, impacts imposed on the multi-layer ceramic electronic part from outside are absorbed by the ceramic outer layer portion and thus impacts to the internal electrode disposal portion are alleviated. Consequently, in



cases where it is handled in bulk by a chip mounting device for example, it is possible to suppress and prevent the occurrence of cracks due to mechanical impacts. Also, if a cracks do occur, it is possible to prevent them reaching the internal electrode disposal portion and occurring across a plurality of electrodes.

Also, the multi-layer ceramic electronic part of the present invention is characterized in that the thickness t_1 of the ceramic outer layer portion is a quarter or more and a third or less of the thickness t_2 of the portion where the internal electrodes are disposed. Therefore, the dimensions of the multi-layer ceramic electronic part are not excessively large and it is possible to attain a multi-layer ceramic electronic part which is compact and highly reliable. Note that by making t_1/t_2 equal $1/4$ or more, sufficient crack prevention effectiveness can be attained, therefore there are no particular deficiencies when limiting t_1/t_2 to the above range.

As described above, since in the multi-layer ceramic electronic part of the present invention the thickness t_1 of the ceramic outer layer portion of the ceramic element forming the multi-layer ceramic electronic part is $1/4$ or more of the thickness t_2 of the portion where the internal electrodes are disposed, in cases where impacts are imparted on the multi-layer ceramic electronic part, these impacts



are absorbed by the ceramic outer layer portion, making it possible to suppress and prevent impacts to the portion where the internal electrodes of the ceramic element are disposed.

Consequently, in the case of a compact ceramic electronic part whose length (L) is 1.0mm or less and height (H) and width (W) are 0.5mm, and is handled in bulk by a chip mounting device for example, as well as it being possible to suppress and prevent the occurrence of cracks due to mechanical impacts, if a crack does occur, it is possible to prevent it reaching the internal electrode disposal portion and occurring across the plurality of electrodes.

Also, where the thickness t_1 of the ceramic outer layer portion is $1/4$ or more and $1/3$ or less of the thickness t_2 of the portion where the internal electrodes are disposed, the dimensions of the multi-layer ceramic electronic part are not excessively large, thus making it possible to attain a multi-layer ceramic electronic part which is compact and highly reliable.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects and advantages of the present invention will become better understood with reference to the following description, appended claims and accompanying drawings, wherein:

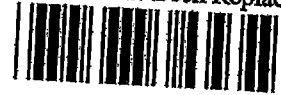


FIG. 1 is a cross-sectional view of a multi-layer ceramic capacitor (multi-layer ceramic electronic part) according to an embodiment of the present invention;

FIG. 2 is a perspective view showing the external structure of the multi-layer ceramic capacitor (multi-layer ceramic electronic part) according to an embodiment of the present invention;

FIG. 3 is a cross-sectional view of a conventional multi-layer ceramic electronic part; and

FIG. 4 (a) and (b) are diagrams illustrating states where a crack has occurred across the plurality of internal electrodes in a conventional multi-layer ceramic electronic part;

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of the present invention will be described below and its characteristics explained in more detail. Note that this embodiment will be explained with respect to a surface-mounted type multi-layer ceramic capacitor as an example.

Fig. 1 is a cross-sectional diagram of the multi-layer ceramic capacitor (multi-layer ceramic electronic part) according to the embodiment of the present invention, and Fig. 2 is a perspective view showing the external structure thereof.



The multi-layer ceramic capacitor 5 of this embodiment, as shown in Fig. 1, has a structure wherein a plurality of capacitance-forming electrodes (internal electrodes) 2 are laminated throughout a ceramic layer 1 so as to face each other, and external electrodes 4 are disposed at each end of the rectangular parallelepiped-shaped ceramic element 3 in which the internal electrodes 2 and ceramic layer 1 are arranged.

Also, the dimensions of the ceramic element 3 of this multi-layer ceramic capacitor 5 are length (L): 0.6mm, height (H): 0.3mm and width (W): 0.3mm. Further, in this multi-layer ceramic capacitor 5, the distance t_1 (i.e. thickness of a ceramic outer layer portion 6) from the internal electrode 2 (2a) of the outermost layer to the surface of the ceramic element 3 is 50 μm (0.050mm), the thickness t_2 of a portion 7 (internal electrode disposal portion) in which the internal electrodes 2 are disposed is 200 μm , the thickness t_1 of the ceramic outer layer portion 6 being one quarter the thickness t_2 of the internal electrode disposal portion 7.

Thereby, where the thickness t_1 of the ceramic outer layer portion 6 is one quarter of t_2 , in cases where impacts are imposed on the multi-layer ceramic capacitor 5 from external sources, these impacts are absorbed by the ceramic outer layer portion, alleviating shocks to the internal electrode

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disposal portion 7. As a result, even when the multi-layer ceramic capacitor 5 is compact, possession of sufficient shock resistance is possible in cases where it is handled in bulk by a chip mounting device for example, and as well as preventing the occurrence of cracks in the ceramic element due to mechanical impacts, even if a crack does happen to occur, it is possible to prevent the crack reaching the internal electrode disposal portion, thus improving reliability.

Note that although the above embodiment has been described in a case where the dimensions of the multi-layer ceramic capacitor are length (L) 0.6mm, height (H) 0.3mm and width (W) 0.3mm, and t_1 is 50 μm and t_2 is 200 μm , similar effects to the multi-layer ceramic capacitor of the above embodiment can also be attained in the case of a multi-layer ceramic capacitor whose dimensions are length (L) 1.0mm, height (H) 0.5mm and width (W) 0.5mm, and where t_1 is 83 μm and t_2 is 332 μm ($t_1/t_2 = 1/4$), .

Table 1 shows the relationship between the values t_1 and t_2 and the ratio of t_1 to t_2 , the rate of occurrence of cracks across the plurality of internal electrodes, and the rate of occurrence of cracks in the ceramic outer layer portion, with respect to multi-layer ceramic capacitors of the present invention and multi-layer ceramic capacitors of comparative examples. Note that in each of the multi-layer

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ceramic capacitors indicated in Table 1, the thicknesses t_1 of the two ceramic outer layer portions at the upper and lower sides of the internal electrode disposal portion are the same.

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Table 1

Sample Number	Dimensions of Ceramic Element (L) x (H) x (W) (mm)	Thickness of Ceramic Outer Layer Portion t_1 (mm)	Thickness of Internal Electrode Disposal Portion t_2 (mm)	t_1/t_2 (-)	Rate of Cracking of Internal Electrode Disposal Portion (%)	Rate of Cracking of Ceramic Outer Layer Portion (%)
*1	0.6 x 0.3 x 0.3	10	280	1/28	10	4
*2	0.6 x 0.3 x 0.3	30	240	1/8	7	3
*3	0.6 x 0.3 x 0.3	50	200	1/4	0	1
4	0.6 x 0.3 x 0.3	70	160	1/2.3	0	0
5	0.6 x 0.3 x 0.3	100	100	1/1	0	0
*6	1.0 x 0.5 x 0.5	25	450	1/18	2	1
*7	1.0 x 0.5 x 0.5	50	400	1/8	1	1
8	1.0 x 0.5 x 0.5	83	334	1/4	0	0
*9	1.0 x 0.5 x 0.5	150	200	1/1.3	0	0
*10	1.6 x 0.8 x 0.8	50	700	1/14	0	0
*11	1.6 x 0.8 x 0.8	100	600	1/6	0	0
*12	1.6 x 0.8 x 0.8	133	534	1/4	0	0
*13	1.6 x 0.8 x 0.8	180	440	1/2.4	0	0

Note also that, in Table 1, those samples with an asterisk (*) before to their numbers are comparative examples, outside the scope of the present invention. As shown in Table 1, in the cases of the multi-layer ceramic capacitors of sample numbers 10, 11, 12 and 13 in which the dimensions of the ceramic element were larger than the scope of the present invention, the occurrence of cracks across the plurality of internal electrodes and cracks in the ceramic outer layer portion was not detected, irrespective of the value of t_1 and the ratio of t_1 and t_2 (t_1/t_2).



However, in the cases of the multi-layer ceramic capacitors in which the dimensions of the ceramic element were within the scope of the present invention (sample numbers 1 to 9), where the value of t_1 and the ratio of t_1 and t_2 (t_1/t_2) were outside the scope of the present invention (sample numbers 1, 2, 3, 6 and 7), cracks occurred across the plurality of internal electrodes and in the ceramic outer layer portion.

On the other hand, in the multi-layer ceramic capacitors in which the value of t_1 and the ratio of t_1 and t_2 (t_1/t_2) were within the scope of the present invention (sample numbers 4, 5, 8 and 9), cracks across the plurality of internal electrodes and cracks in the ceramic outer layer portion were not detected.

Note that although the above embodiment was described using multi-layer ceramic capacitors as examples, the present invention is not limited thereto and may be applied to various types of multi-layer ceramic electronic parts having a structure wherein electrodes are disposed within a ceramic element, in which cases it is possible to attain the same effects as in the embodiment described above.

The present invention is not limited to the above embodiment in other respects as well, so that various applications and configurations are possible so long as they are within the scope of the concept of the present invention

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with respect to the specific dimensions and shape of the ceramic element and the arrangement of the internal electrodes.

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WHAT IS CLAIMED IS:

1. A multi-layer ceramic electronic part in which a plurality of electrodes (internal electrodes) are laminated so as to face each other via a ceramic layer within a ceramic element whose length (L), height (H) and width (W) are

$$L \leq 1.0\text{mm}$$

$$H \leq 0.5\text{mm}$$

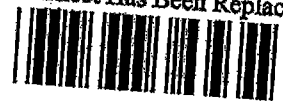
$$W \leq 0.5\text{mm},$$

and a distance (thickness of a ceramic outer layer portion) t_1 from an internal electrode of an outermost layer to a surface of the ceramic element is 0.10mm or less, wherein:

the thickness t_1 of the ceramic outer layer portion is a quarter or more of a thickness t_2 of a portion where the internal electrodes are disposed.

2. The multi-layer ceramic electronic part according to claim 1, wherein the thickness t_1 of the ceramic outer layer portion is a quarter or more and a third or less of the thickness t_2 of the portion where the internal electrodes are disposed.

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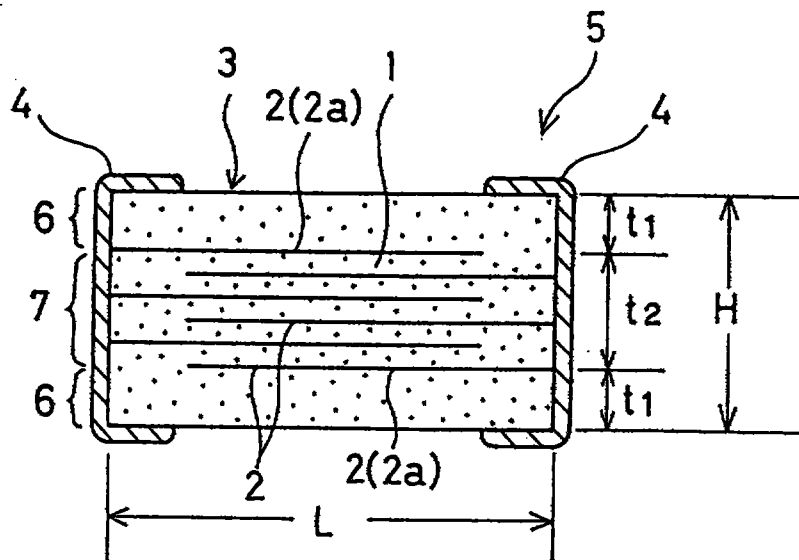
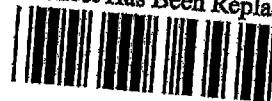
ABSTRACT OF THE DISCLOSURE

A highly reliable multi-layer ceramic electronic part which is compact, in which cracks tend not to occur in the ceramic element even in cases where it is handled in bulk by a chip mounting device, and which is highly reliable, is provided. The thickness t_1 of a ceramic outer layer portion 6 of the multi-layer ceramic electronic part, in which a plurality of electrodes (internal electrodes) are disposed within a ceramic element whose length $L \leq 1.0\text{mm}$, height $H \leq 0.5\text{mm}$ and width $W \leq 0.5\text{mm}$, and the distance (thickness of the ceramic outer layer portion 6) t_1 from the internal electrode 2 (2a) of the outermost layer to the surface of the ceramic element 3 is 0.15mm or less, is $1/4$ or more of the thickness t_2 of the portion where the internal electrodes 2 are disposed.

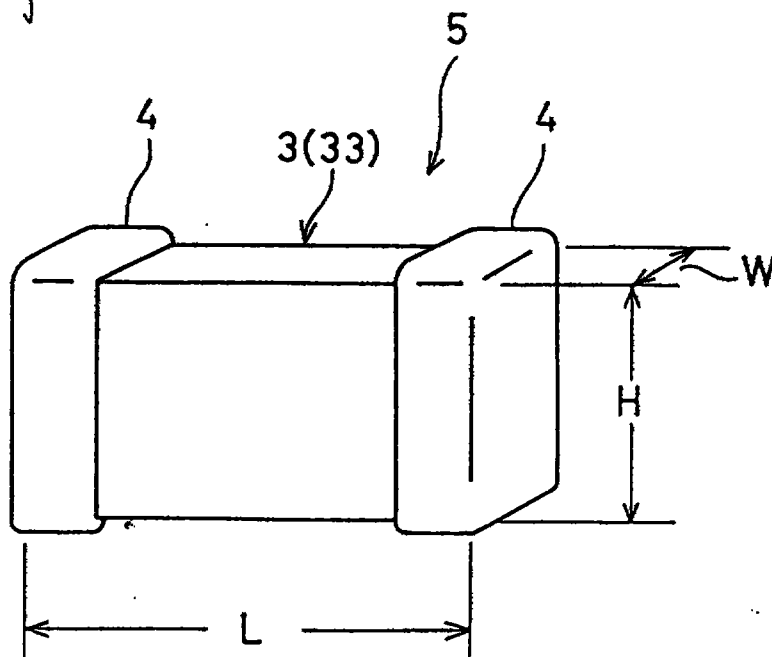
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【図1】 Fig. 1

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【図2】 Fig. 2

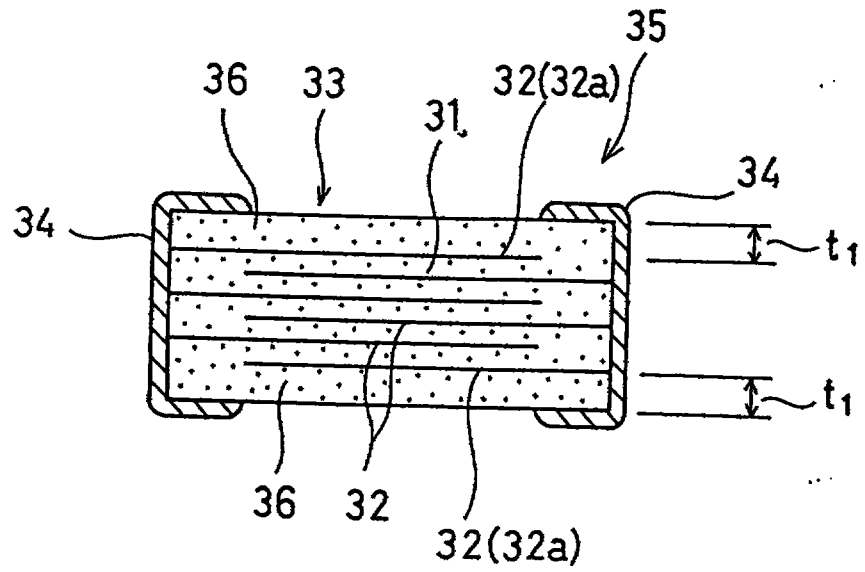


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【図3】 Fig. 3



【図4】

Fig. 4 (a)

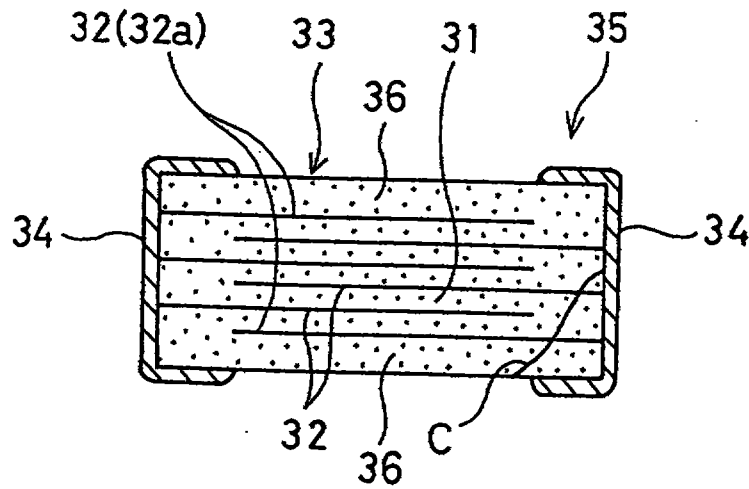
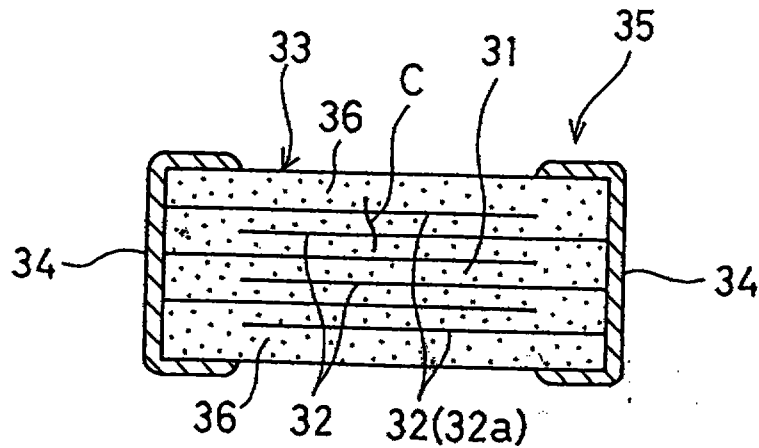


Fig. 4 (b)





MULTI-LAYER CERAMIC ELECTRONIC PART

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BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to electronic parts, in particular to multi-layer ceramic electronic parts having a structure in which a plurality of internal electrodes are disposed throughout a ceramic layer in a ceramic element.

DESCRIPTION OF THE RELATED ART

In one type of surface-mounted type ceramic electronic part, for example as shown in Fig. 3, at both ends of a rectangular parallelopiped-shaped ceramic element 33 in which a plurality of electrodes (internal electrodes) 32 are disposed so as to face each other via a ceramic layer 31, there are ceramic electronic parts (multi-layer ceramic capacitors) 35 which have a structure wherein external electrodes 34 are disposed so as to be conductive with the internal electrodes 32.

This type of ceramic electronic part has become more and more miniaturized with the continued miniaturization of electronic devices, and has resulted in an extremely compact ceramic electronic part such as the ceramic element 33 shown in Fig. 2, whose length (L) is 1.0mm or less and height (H) and width (W) are 0.5mm or less. Also, in such a ceramic electronic part, the distance (thickness of a ceramic outer

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layer portion 36) t_1 from the internal electrode 32 (32a) of the outermost layer to the surface of the ceramic element 33 is very small at 0.10mm or less.

However, in the field of miniaturization described above, ceramic electronic parts in which the thickness t_1 of the ceramic outer layer portion 36 is small have little mechanical strength (resistive strength etc.), and in a case where they are handled in bulk by a chip mounting device for example, because cracks in the ceramic element occur easily due to mechanical impacts, as shown in Fig. 4(a) and (b), cracks C occur across the plurality of internal electrodes 32, resulting in the problem of the desired characteristics becoming unattainable.

SUMMARY OF THE INVENTION

The present invention is intended to solve the above problem, and has as its object to provide a highly reliable multi-layer ceramic electronic part which is compact, has sufficient mechanical strength (resistive strength etc.), and in cases where it is handled in bulk by a chip mounting device, is not susceptible to cracks in the ceramic element due to mechanical impacts.

In order to achieve the above object, the inventors performed various tests and studies and found that, by setting the thickness of the ceramic outer layer portion to



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a predetermined ratio with respect to the thickness of the portion where the internal electrodes were disposed, resistive strength etc. could be improved and it was possible to suppress the occurrence of cracks. The present invention was arrived at as a result of this discovery, after further tests and studies.

In other words, the multi-layer ceramic electronic part of the present invention, in which, in a ceramic element whose length (L) is 1.0mm or less, height (H) is 0.5mm or less and width (W) is 0.5mm or less, a plurality of electrodes (internal electrodes) are laminated so as to face each other via a ceramic layer and a distance (thickness of a ceramic outer layer portion) t_1 from an internal electrode of an outermost layer to a surface of the ceramic element is 0.10mm or less, it characterized in that the thickness t_1 of the ceramic outer layer portion is a quarter or more of a thickness t_2 of a portion where the internal electrodes are disposed.

As described above, by setting the thickness t_1 of the ceramic outer layer portion to one quarter or more of the thickness t_2 of the portion where the internal electrodes are disposed, impacts imposed on the multi-layer ceramic electronic part from outside are absorbed by the ceramic outer layer portion and thus impacts to the internal electrode disposal portion are alleviated. Consequently, in

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cases where it is handled in bulk by a chip mounting device for example, it is possible to suppress and prevent the occurrence of cracks due to mechanical impacts. Also, if a cracks do occur, it is possible to prevent them reaching the internal electrode disposal portion and occurring across a plurality of electrodes.

Also, the multi-layer ceramic electronic part of the present invention is characterized in that the thickness t_1 of the ceramic outer layer portion is a quarter or more and a third or less of the thickness t_2 of the portion where the internal electrodes are disposed. Therefore, the dimensions of the multi-layer ceramic electronic part are not excessively large and it is possible to attain a multi-layer ceramic electronic part which is compact and highly reliable. Note that by making t_1/t_2 equal $1/4$ or more, sufficient crack prevention effectiveness can be attained, therefore there are no particular deficiencies when limiting t_1/t_2 to the above range.

As described above, since in the multi-layer ceramic electronic part of the present invention the thickness t_1 of the ceramic outer layer portion of the ceramic element forming the multi-layer ceramic electronic part is $1/4$ or more of the thickness t_2 of the portion where the internal electrodes are disposed, in cases where impacts are imparted on the multi-layer ceramic electronic part, these impacts



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are absorbed by the ceramic outer layer portion, making it possible to suppress and prevent impacts to the portion where the internal electrodes of the ceramic element are disposed.

Consequently, in the case of a compact ceramic electronic part whose length (L) is 1.0mm or less and height (H) and width (W) are 0.5mm, and is handled in bulk by a chip mounting device for example, as well as it being possible to suppress and prevent the occurrence of cracks due to mechanical impacts, if a crack does occur, it is possible to prevent it reaching the internal electrode disposal portion and occurring across the plurality of electrodes.

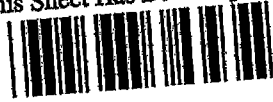
Also, where the thickness t_1 of the ceramic outer layer portion is $1/4$ or more and $1/3$ or less of the thickness t_2 of the portion where the internal electrodes are disposed, the dimensions of the multi-layer ceramic electronic part are not excessively large, thus making it possible to attain a multi-layer ceramic electronic part which is compact and highly reliable.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects and advantages of the present invention will become better understood with reference to the following description, appended claims and accompanying drawings, wherein:

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FIG. 1 is a cross-sectional view of a multi-layer ceramic capacitor (multi-layer ceramic electronic part) according to an embodiment of the present invention;

FIG. 2 is a perspective view showing the external structure of the multi-layer ceramic capacitor (multi-layer ceramic electronic part) according to an embodiment of the present invention;

FIG. 3 is a cross-sectional view of a conventional multi-layer ceramic electronic part; and

FIG. 4 (a) and (b) are diagrams illustrating states where a crack has occurred across the plurality of internal electrodes in a conventional multi-layer ceramic electronic part;

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of the present invention will be described below and its characteristics explained in more detail. Note that this embodiment will be explained with respect to a surface-mounted type multi-layer ceramic capacitor as an example.

Fig. 1 is a cross-sectional diagram of the multi-layer ceramic capacitor (multi-layer ceramic electronic part) according to the embodiment of the present invention, and Fig. 2 is a perspective view showing the external structure thereof.

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The multi-layer ceramic capacitor 5 of this embodiment, as shown in Fig. 1, has a structure wherein a plurality of capacitance-forming electrodes (internal electrodes) 2 are laminated throughout a ceramic layer 1 so as to face each other, and external electrodes 4 are disposed at each end of the rectangular parallelepiped-shaped ceramic element 3 in which the internal electrodes 2 and ceramic layer 1 are arranged.

Also, the dimensions of the ceramic element 3 of this multi-layer ceramic capacitor 5 are length (L): 0.6mm, height (H): 0.3mm and width (W): 0.3mm. Further, in this multi-layer ceramic capacitor 5, the distance t_1 (i.e. thickness of a ceramic outer layer portion 6) from the internal electrode 2 (2a) of the outermost layer to the surface of the ceramic element 3 is 50 μm (0.050mm), the thickness t_2 of a portion 7 (internal electrode disposal portion) in which the internal electrodes 2 are disposed is 200 μm , the thickness t_1 of the ceramic outer layer portion 6 being one quarter the thickness t_2 of the internal electrode disposal portion 7.

Thereby, where the thickness t_1 of the ceramic outer layer portion 6 is one quarter of t_2 , in cases where impacts are imposed on the multi-layer ceramic capacitor 5 from external sources, these impacts are absorbed by the ceramic outer layer portion, alleviating shocks to the internal electrode

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disposal portion 7. As a result, even when the multi-layer ceramic capacitor 5 is compact, possession of sufficient shock resistance is possible in cases where it is handled in bulk by a chip mounting device for example, and as well as preventing the occurrence of cracks in the ceramic element due to mechanical impacts, even if a crack does happen to occur, it is possible to prevent the crack reaching the internal electrode disposal portion, thus improving reliability.

Note that although the above embodiment has been described in a case where the dimensions of the multi-layer ceramic capacitor are length (L) 0.6mm, height (H) 0.3mm and width (W) 0.3mm, and t_1 is 50 μm and t_2 is 200 μm , similar effects to the multi-layer ceramic capacitor of the above embodiment can also be attained in the case of a multi-layer ceramic capacitor whose dimensions are length (L) 1.0mm, height (H) 0.5mm and width (W) 0.5mm, and where t_1 is 83 μm and t_2 is 332 μm ($t_1/t_2 = 1/4$), .

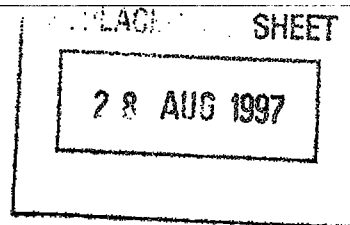
Table 1 shows the relationship between the values t_1 and t_2 and the ratio of t_1 to t_2 , the rate of occurrence of cracks across the plurality of internal electrodes, and the rate of occurrence of cracks in the ceramic outer layer portion, with respect to multi-layer ceramic capacitors of the present invention and multi-layer ceramic capacitors of comparative examples. Note that in each of the multi-layer

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ceramic capacitors indicated in Table 1, the thicknesses t_1 of the two ceramic outer layer portions at the upper and lower sides of the internal electrode disposal portion are the same.

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Table 1

Sample Number	Dimensions of Ceramic Element (L) x (H) x (W) (mm)	Thickness of Ceramic Outer Layer Portion t_1 (mm)	Thickness of Internal Electrode Disposal Portion t_2 (mm)	t_1/t_2 (-)	Rate of Cracking of Internal Electrode Disposal Portion (%)	Rate of Cracking of Ceramic Outer Layer Portion (%)
*1	$0.6 \times 0.3 \times 0.3$	10	280	1/28	10	4
*2	$0.6 \times 0.3 \times 0.3$	30	240	1/8	7	3
*3	$0.6 \times 0.3 \times 0.3$	50	200	1/4	0	1
4	$0.6 \times 0.3 \times 0.3$	70	160	1/2.3	0	0
5	$0.6 \times 0.3 \times 0.3$	100	100	1/1	0	0
*6	$1.0 \times 0.5 \times 0.5$	25	450	1/18	2	1
*7	$1.0 \times 0.5 \times 0.5$	50	400	1/8	1	1
8	$1.0 \times 0.5 \times 0.5$	83	334	1/4	0	0
*9	$1.0 \times 0.5 \times 0.5$	150	200	1/1.3	0	0
*10	$1.6 \times 0.8 \times 0.8$	50	700	1/14	0	0
*11	$1.6 \times 0.8 \times 0.8$	100	600	1/6	0	0
*12	$1.6 \times 0.8 \times 0.8$	133	534	1/4	0	0
*13	$1.6 \times 0.8 \times 0.8$	180	440	1/2.4	0	0

Note also that, in Table 1, those samples with an asterisk (*) before to their numbers are comparative examples, outside the scope of the present invention. As shown in Table 1, in the cases of the multi-layer ceramic capacitors of sample numbers 10, 11, 12 and 13 in which the dimensions of the ceramic element were larger than the scope of the present invention, the occurrence of cracks across the plurality of internal electrodes and cracks in the ceramic outer layer portion was not detected, irrespective of the value of t_1 and the ratio of t_1 and t_2 (t_1/t_2).



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However, in the cases of the multi-layer ceramic capacitors in which the dimensions of the ceramic element were within the scope of the present invention (sample numbers 1 to 9), where the value of t_1 and the ratio of t_1 and t_2 (t_1/t_2) were outside the scope of the present invention (sample numbers 1, 2, 3, 6 and 7), cracks occurred across the plurality of internal electrodes and in the ceramic outer layer portion.

On the other hand, in the multi-layer ceramic capacitors in which the value of t_1 and the ratio of t_1 and t_2 (t_1/t_2) were within the scope of the present invention (sample numbers 4, 5, 8 and 9), cracks across the plurality of internal electrodes and cracks in the ceramic outer layer portion were not detected.

Note that although the above embodiment was described using multi-layer ceramic capacitors as examples, the present invention is not limited thereto and may be applied to various types of multi-layer ceramic electronic parts having a structure wherein electrodes are disposed within a ceramic element, in which cases it is possible to attain the same effects as in the embodiment described above.

The present invention is not limited to the above embodiment in other respects as well, so that various applications and configurations are possible so long as they are within the scope of the concept of the present invention

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with respect to the specific dimensions and shape of the ceramic element and the arrangement of the internal electrodes.

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WHAT IS CLAIMED IS:

1. A multi-layer ceramic electronic part in which a plurality of electrodes (internal electrodes) are laminated so as to face each other via a ceramic layer within a ceramic element whose length (L), height (H) and width (W) are

$$L \leq 1.0\text{mm}$$

$$H \leq 0.5\text{mm}$$

$$W \leq 0.5\text{mm},$$

and a distance (thickness of a ceramic outer layer portion) t_1 from an internal electrode of an outermost layer to a surface of the ceramic element is 0.10mm or less, wherein:

the thickness t_1 of the ceramic outer layer portion is a quarter or more of a thickness t_2 of a portion where the internal electrodes are disposed.

2. The multi-layer ceramic electronic part according to claim 1, wherein the thickness t_1 of the ceramic outer layer portion is a quarter or more and a third or less of the thickness t_2 of the portion where the internal electrodes are disposed.

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14MULTI-LAYER CERMAIC ELECTRONIC PART

ABSTRACT OF THE DISCLOSURE

A highly reliable multi-layer ceramic electronic part which is compact, in which cracks tend not to occur in the ceramic element even in cases where it is handled in bulk by a chip mounting device, and which is highly reliable, is provided. The thickness t_1 of a ceramic outer layer portion 6 of the multi-layer ceramic electronic part, in which a plurality of electrodes (internal electrodes) are disposed within a ceramic element whose length $L \leq 1.0\text{mm}$, height $H \leq 0.5\text{mm}$ and width $W \leq 0.5\text{mm}$, and the distance (thickness of the ceramic outer layer portion 6) t_1 from the internal electrode 2 (2a) of the outermost layer to the surface of the ceramic element 3 is 0.15mm or less, is $1/4$ or more of the thickness t_2 of the portion where the internal electrodes 2 are disposed.

FIG. 1

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FIG. 1

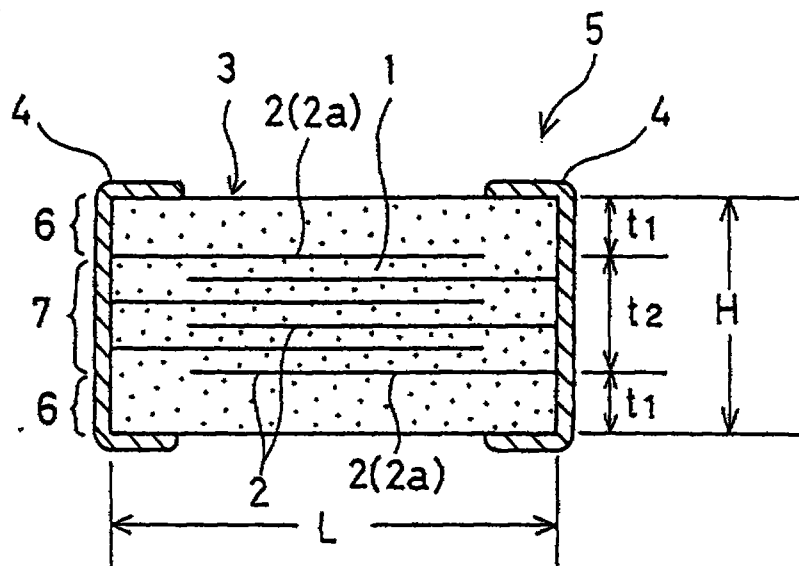
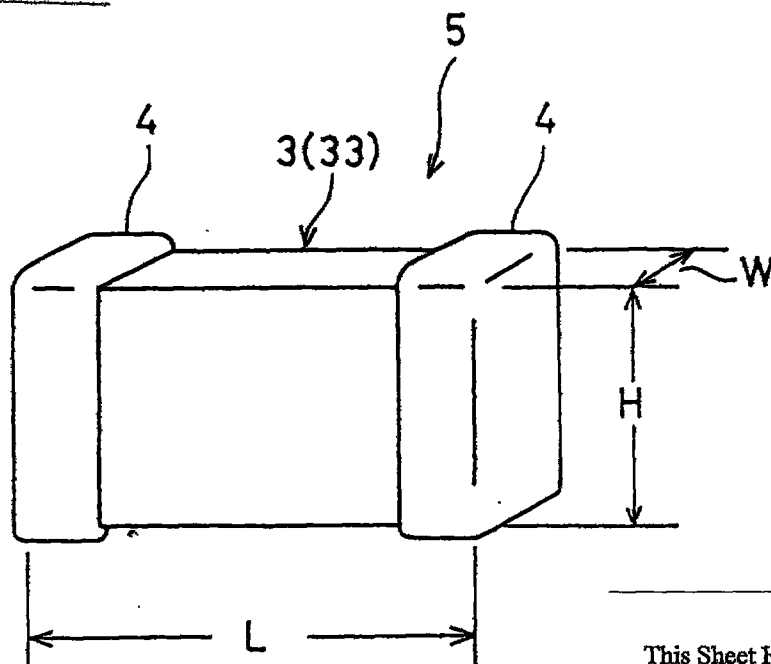


FIG. 2



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FIG. 3

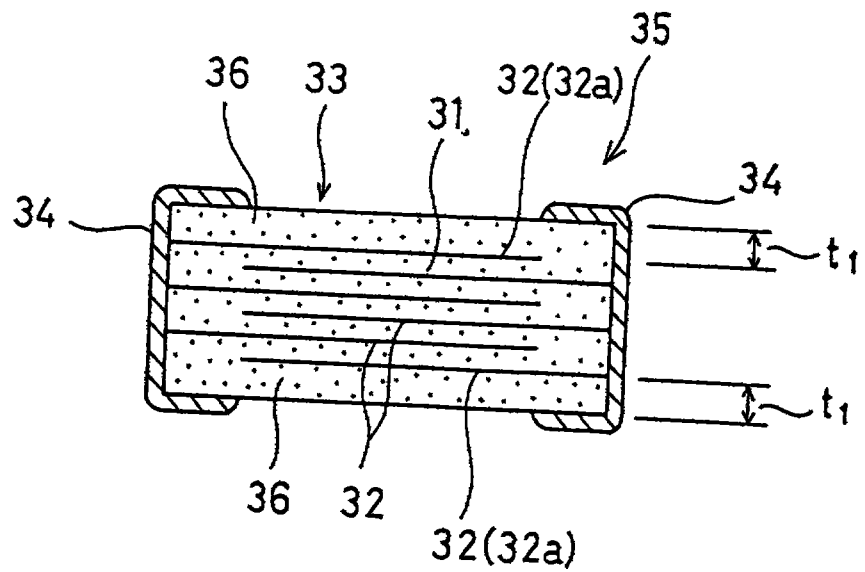


FIG. 4A

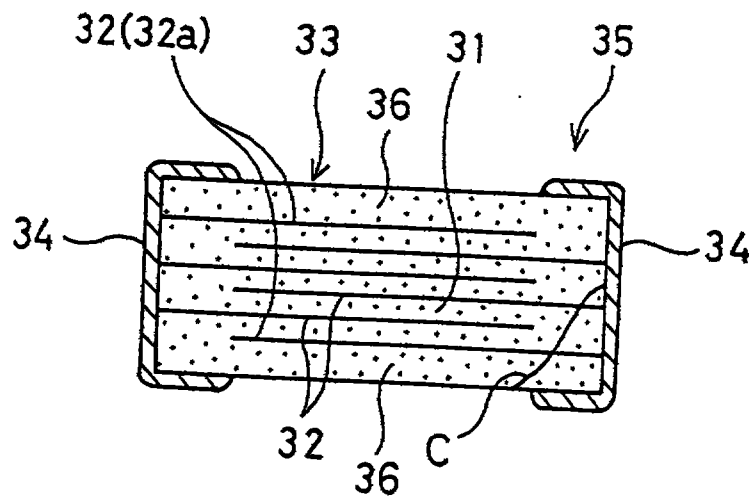
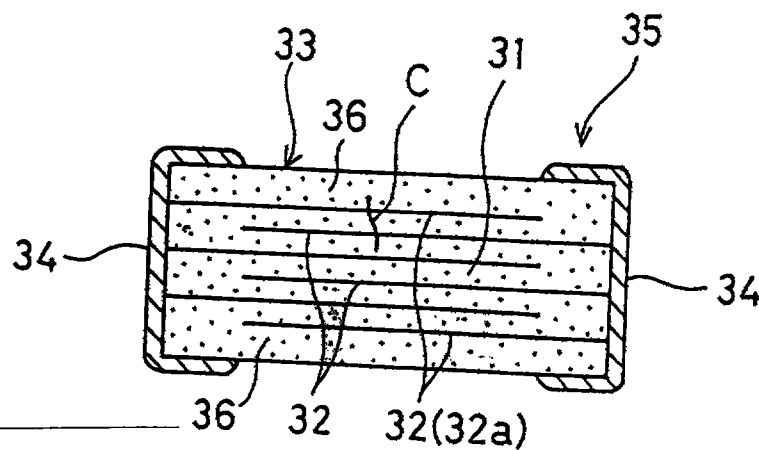


FIG. 4B



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MULTI-LAYER CERAMIC ELECTRONIC PART

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to electronic parts, in particular to multi-layer ceramic electronic parts having a structure in which a plurality of internal electrodes are disposed throughout a ceramic layer in a ceramic element.

DESCRIPTION OF THE RELATED ART

One type of surface-mounted type ceramic electronic part, for example as shown in Fig. 3, has a rectangular parallelepiped-shaped ceramic element 33 in which a plurality of electrodes (internal electrodes) 32 are disposed so as to face each other via a ceramic layer 31.

At both ends, external electrodes 34 are disposed so as to be conductive with the internal electrodes 32, to form a multi-layer ceramic capacitor 35.

This type of ceramic electronic part has become more and more miniaturized with the continued miniaturization of electronic devices, which has resulted in an extremely compact ceramic electronic part such as the ceramic element 33 shown in Fig. 2, whose length (L) is 1.0mm or less and height (H) and width (W) are 0.5mm or less. Also, in such a ceramic electronic part, the distance (thickness of a ceramic outer

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layer portion 36) t_1 from the internal electrode 32 (32a) of the outermost layer to the surface of the ceramic element 33 is very small at 0.10mm or less.

However, in the field of miniaturization described above, ceramic electronic parts in which the thickness t_1 of the ceramic outer layer portion 36 is small have little mechanical strength (resistive strength etc.), and in a case where they are handled in bulk by a chip mounting device for example, cracks in the ceramic element occur easily due to mechanical impacts, as shown in Fig. 4(a) and (b). Thus, for example, cracks C can occur across the plurality of internal electrodes 32, resulting in the problem that the desired electrical characteristics become unattainable.

SUMMARY OF THE INVENTION

The present invention is intended to solve the above problem, and advantageously can provide a highly reliable multi-layer ceramic electronic part which is compact, has sufficient mechanical strength (resistive strength etc.), and in cases where it is handled in bulk by a chip mounting device, is not susceptible to cracks in the ceramic element due to mechanical impacts.

In order to achieve the above result, the inventors performed various tests and studies and found that, by setting the thickness of the ceramic outer layer portion to

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a predetermined ratio with respect to the thickness of the portion where the internal electrodes were disposed, resistive strength, etc., could be improved and it was possible to suppress the occurrence of cracks. The present invention was arrived at as a result of this discovery, after further tests and studies.

In a multi-layer ceramic electronic part according to a first aspect of the present invention, in a ceramic element

whose length (L) is 1.0mm or less, height (H) is 0.5mm or less and width (W) is 0.5mm or less, a plurality of electrodes (internal electrodes) are laminated so as to face each other via a ceramic layer at a distance (thickness of a ceramic outer layer portion) t_1 from an internal electrode of an outermost layer to a surface of the ceramic element is 0.10mm or less, and the thickness t_1 of the ceramic outer layer portion is a quarter or more of a thickness t_2 of a portion where the internal electrodes are disposed.

As described above, by setting the thickness t_1 of the ceramic outer layer portion to one quarter or more of the thickness t_2 of the portion where the internal electrodes are disposed, impacts imposed on the multi-layer ceramic electronic part from outside are absorbed by the ceramic outer layer portion and thus impacts to the

portion

where the internal electrodes are disposed are alleviated. Consequently, in

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cases where it is handled in bulk by a chip mounting device for example, it is possible to suppress and prevent the occurrence of cracks due to mechanical impacts. Also, if cracks do occur, it is possible to prevent them from reaching the internal electrode portion and from occurring across a plurality of electrodes.

Also, according to another aspect of the present invention, the multi-layer ceramic electronic part is characterized in that the thickness t_1

of the ceramic outer layer portion is from a quarter up to a third of the thickness t_2 of the portion where the internal electrodes are disposed. Therefore, the dimensions of the multi-layer ceramic electronic part are not excessively large and it is possible to attain a multi-layer ceramic electronic part which is compact and highly reliable. Note that by making t_1/t_2 equal $1/4$ or more, sufficient crack prevention effectiveness can be attained, therefore there are no particular deficiencies when limiting t_1/t_2 to the above range.

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BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects and advantages of the present invention will become better understood with reference to the following description, appended claims and accompanying drawings, wherein:

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FIG. 1 is a cross-sectional view of a multi-layer ceramic capacitor (multi-layer ceramic electronic part) according to an embodiment of the present invention;

FIG. 2 is a perspective view showing the external structure of the multi-layer ceramic capacitor (multi-layer ceramic electronic part) according to an embodiment of the present invention;

FIG. 3 is a cross-sectional view of a conventional multi-layer ceramic electronic part; and

FIG. 4 (a) and (b) are diagrams illustrating states where a crack has occurred across the plurality of internal electrodes in a conventional multi-layer ceramic electronic part;

DETAILED DESCRIPTION OF AN EMBODIMENT

An embodiment of the present invention will be described below and its characteristics explained in more detail. Note that this embodiment will be explained with respect to a surface-mounted type multi-layer ceramic capacitor as an example.

Fig. 1 is a cross-sectional diagram of the multi-layer ceramic capacitor (multi-layer ceramic electronic part) according to an embodiment of the present invention, and Fig. 2 is a perspective view showing the external structure thereof.

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The multi-layer ceramic capacitor 5 of this embodiment, as shown in Fig. 1, has a structure wherein a plurality of capacitance-forming electrodes (internal electrodes) 2 are laminated throughout a ceramic layer 1 so as to face each other, and external electrodes 4 are disposed at each end of the rectangular parallelepiped-shaped ceramic element 3 in which the internal electrodes 2 and ceramic layer 1 are arranged.

Also, the dimensions of the ceramic element 3 of this multi-layer ceramic capacitor 5 are length (L): 0.6mm, height (H): 0.3mm and width (W): 0.3mm. Further, in this multi-layer ceramic capacitor 5, the distance t_1 (i.e. thickness of a ceramic outer layer portion 6) from the internal electrode 2 (2a) of the outermost layer to the surface of the ceramic element 3 is 50 μm (0.050mm), the thickness t_2 of a portion 7 (internal electrode disposal portion) in which the internal electrodes 2 are disposed is 200 μm , the thickness t_1 of the ceramic outer layer portion 6 being one quarter the thickness t_2 of the internal electrode portion 7.

Thereby, where the thickness t_1 of the ceramic outer layer portion 6 is one quarter of t_2 , in cases where impacts are imposed on the multi-layer ceramic capacitor 5 from external sources, these impacts are absorbed by the ceramic outer layer portion, alleviating shocks to the internal electrode

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disposal portion 7. As a result, even when the multi-layer ceramic capacitor 5 is compact, possession of sufficient shock resistance is possible in cases where it is handled in bulk by a chip mounting device for example. As well as preventing the occurrence of cracks in the ceramic element due to mechanical impacts, even if a crack does happen to occur, it is possible to prevent the crack reaching the internal electrode portion, thus improving reliability.

Note that although the above embodiment has been described in a case where the dimensions of the multi-layer ceramic capacitor are length (L) 0.6mm, height (H) 0.3mm and width (W) 0.3mm, and t_1 is 50 μm and t_2 is 200 μm , similar effects to the multi-layer ceramic capacitor of the above embodiment can also be attained in the case of a multi-layer ceramic capacitor whose dimensions are length (L) 1.0mm, height (H) 0.5mm and width (W) 0.5mm, and where t_1 is 83 μm and t_2 is 332 μm ($t_1/t_2 = 1/4$).

Table 1 shows the relationship between the values t_1 and t_2 and the ratio of t_1 to t_2 , the rate of occurrence of cracks across the plurality of internal electrodes, and the rate of occurrence of cracks in the ceramic outer layer portion, with respect to multi-layer ceramic capacitors of the present invention and multi-layer ceramic capacitors of comparative examples. Note that in each of the multi-layer

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ceramic capacitors indicated in Table 1, the thicknesses t_1 of the two ceramic outer layer portions at the upper and lower sides of the internal electrode portion are the same.

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Table 1

Sample Number	Dimensions of Ceramic Element (L) x (H) x (W) (mm)	Thickness of Ceramic Outer Layer Portion t_1 (mm)	Thickness of Internal Electrode Portion t_2 (mm)	t_1/t_2 (-)	Rate of Cracking of Internal Electrode Portion (%)	Rate of Cracking of Ceramic Outer Layer Portion (%)
*1	$0.6 \times 0.3 \times 0.3$	10	280	1/28	10	4
*2	$0.6 \times 0.3 \times 0.3$	30	240	1/8	7	3
*3	$0.6 \times 0.3 \times 0.3$	50	200	1/4	0	1
4	$0.6 \times 0.3 \times 0.3$	70	160	1/2.3	0	0
5	$0.6 \times 0.3 \times 0.3$	100	100	1/1	0	0
*6	$1.0 \times 0.5 \times 0.5$	25	450	1/18	2	1
*7	$1.0 \times 0.5 \times 0.5$	50	400	1/8	1	1
8	$1.0 \times 0.5 \times 0.5$	83	334	1/4	0	0
*9	$1.0 \times 0.5 \times 0.5$	150	200	1/1.3	0	0
*10	$1.6 \times 0.8 \times 0.8$	50	700	1/14	0	0
*11	$1.6 \times 0.8 \times 0.8$	100	600	1/6	0	0
*12	$1.6 \times 0.8 \times 0.8$	133	534	1/4	0	0
*13	$1.6 \times 0.8 \times 0.8$	180	440	1/2.4	0	0

Note also that, in Table 1, those samples with an asterisk (*) before to their numbers are comparative examples, outside the scope of the present invention. As shown in Table 1, in the cases of the multi-layer ceramic capacitors of sample numbers 10, 11, 12 and 13 in which the dimensions of the ceramic element were larger than the scope of the present invention, the occurrence of cracks across the plurality of internal electrodes and cracks in the ceramic outer layer portion was not detected, irrespective of the value of t_1 and the ratio of t_1 and t_2 (t_1/t_2).

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However, in the cases of the multi-layer ceramic capacitors in which the dimensions of the ceramic element were within the scope of the present invention (sample numbers 1 to 9), where the value of t_1 and the ratio of t_1 and t_2 (t_1/t_2) were outside the scope of the present invention (sample numbers 1, 2, 3, 6 and 7), cracks occurred across the plurality of internal electrodes and in the ceramic outer layer portion.

On the other hand, in the multi-layer ceramic capacitors in which the value of t_1 and the ratio of t_1 and t_2 (t_1/t_2) were within the scope of the present invention (sample numbers 4, 5, 8 and 9), cracks across the plurality of internal electrodes and cracks in the ceramic outer layer portion were not detected.

Note that although the above embodiment was described using multi-layer ceramic capacitors as examples, the present invention is not limited thereto and may be applied to various types of multi-layer ceramic electronic parts having a structure wherein electrodes are disposed within a ceramic element, in which cases it is possible to attain the same effects as in the embodiment described above.

The present invention is not limited to the above embodiment in other respects as well, so that various applications and configurations are possible so long as they are within the scope of the concept of the present invention

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with respect to the specific dimensions and shape of the ceramic element and the arrangement of the internal electrodes.



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WHAT IS CLAIMED IS:

1. A multi-layer ceramic electronic part in which a plurality of electrodes (internal electrodes) are laminated so as to face each other via a ceramic layer within a ceramic element whose length (L), height (H) and width (W) are

$$L \leq 1.0\text{mm}$$

$$H \leq 0.5\text{mm}$$

$$W \leq 0.5\text{mm},$$

and a distance (thickness of a ceramic outer layer portion) t_1 from an internal electrode of an outermost layer to a surface of the ceramic element is 0.10mm or less, wherein:

the thickness t_1 of the ceramic outer layer portion is a quarter or more of a thickness t_2 of a portion where the internal electrodes are disposed.

2. The multi-layer ceramic electronic part according to claim 1, wherein the thickness t_1 of the ceramic outer layer portion is a quarter or more and a third or less of the thickness t_2 of the portion where the internal electrodes are disposed.

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MULTI-LAYER CERAMIC ELECTRONIC PART

ABSTRACT OF THE DISCLOSURE

A highly reliable multi-layer ceramic electronic part which is compact, in which cracks tend not to occur in the ceramic element even in cases where it is handled in bulk by a chip mounting device.

A plurality of electrodes (internal electrodes) are disposed within a ceramic element whose length $L \leq 1.0\text{mm}$, height $H \leq 0.5\text{mm}$ and width $W \leq 0.5\text{mm}$. The thickness t_1 of a ceramic outer layer portion of the multi-layer ceramic electronic part, is 0.15 mm or less. The thickness of the ceramic outer layer portion t_1 and the thickness t_2 of the portion where the internal electrodes are disposed have the relationship $1/4 t_2 \leq t_1 \leq 1/3 t_2$.

FIG. 1

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FIG. 1

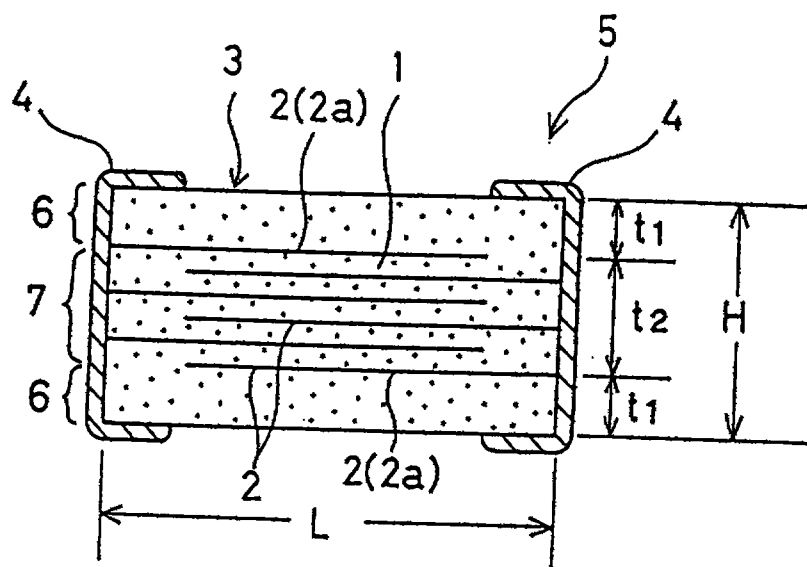
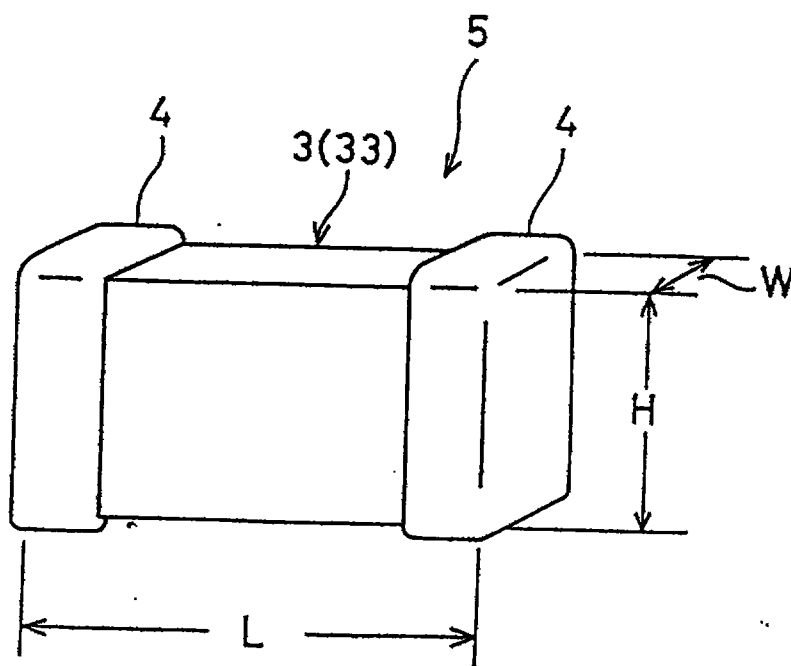


FIG. 2



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FIG. 3

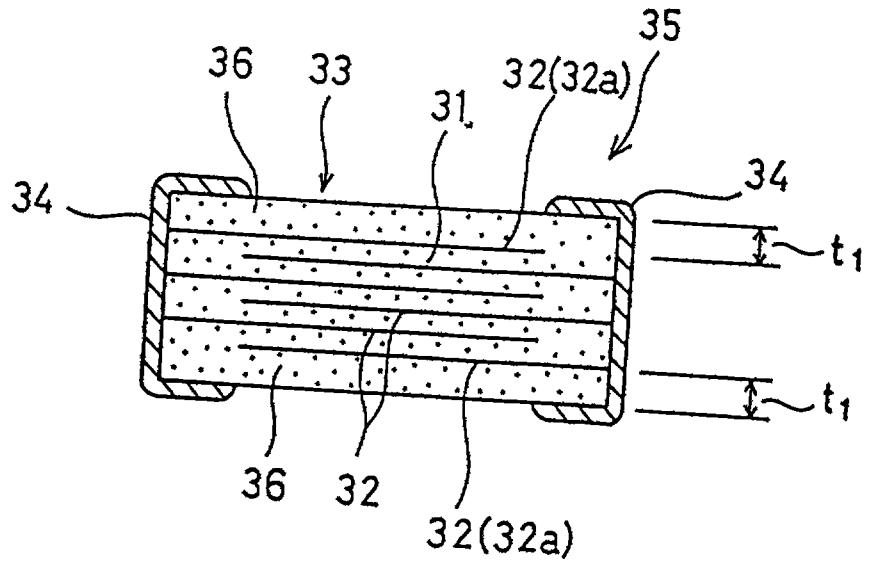


FIG. 4A

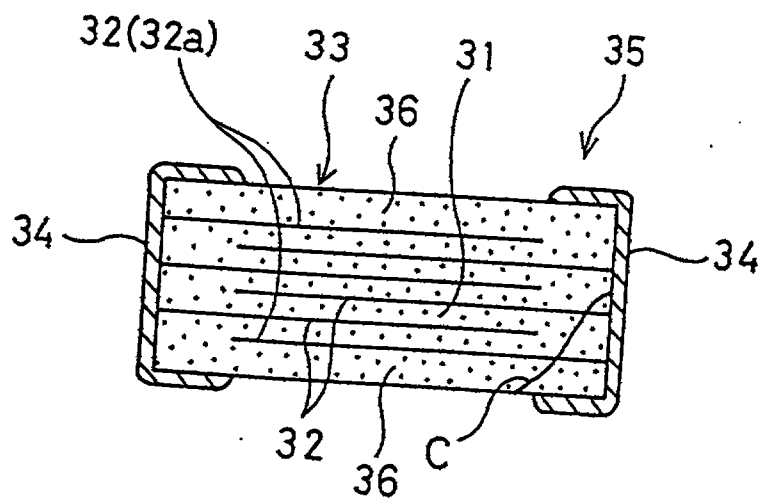


FIG. 4B

